

CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-41

December 12, 1977

1. Name of fault: Whittier fault.

2. Location of fault:

The fault lies along the southwestern side of the Puente Hills, within the Prado Dam, Yorba Linda, La Habra, and Whittier quadrangles, Orange and Los Angeles Counties, California (Figure 1).

3. Reason for evaluation:

This fault is located within the 1977 study area of the 10-year program for fault evaluation.

4. List of references:

Daviess, S.M., and A.O. Woodford, 1949, Geology of the northwestern Puente Hills, Los Angeles County, California: U.S. Geological Survey Oil and Gas Preliminary Map 83. Map scale 1:12,000.

(Their map is very generalized in regard to faults.)

Durham, D.L., and R.F. Yerkes, 1964, Geology and oil resources of the eastern Puente Hills area, southern California: U.S. Geological Survey Professional Paper 420-B, 62 p. Map scale 1:24,000.

(A moderately detailed map and good description of the fault zone. This report covers only the eastern half of the Whittier fault.)

English, W.A., 1926, Geology and oil resources of the Puente Hills region, southern California: U.S. Geological Survey Bulletin 768, 110 p. Map scale 1:62,500.

(His map is very generalized. He gives a brief discussion of the fault on p. 56, but says nothing about recency of activity.)

Higgins, J.W., editor, 1958, A guide to the geology and oil fields of the Los Angeles and Ventura regions: Annual Meeting, Pacific Section, American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, March 10-13, 1958. Map scale 1:62,500.

(Very generalized maps, no descriptions of use in fault evaluation.)

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1. Scale 1:750,000.

Lamar, D.L., 1972, Microseismicity and recent tectonic activity in Whittier fault area, California: Earth Science Research Corporation Final Technical Report for U.S. Geological Survey, National Center for Earthquake Research, 44 p. Map scale 1:48,000.

(His map is generalized from the maps of earlier workers. He gives a good discussion of recency of activity along the Whittier fault on p. 23-27. On the basis of his microseismic data, he states, "... the Whittier fault must be considered active.")

Miller, R.V., Tan, S.S., Chapman, R.H., and Chase, G.W., 1977, Recency of faulting of major faults in Orange County, California: California Division of Mines and Geology Open File Report (in review), 70 p. Map scale 1:12,000.

(This is the most recent study of the part of the Whittier fault that lies within Orange County. The study was directed specifically toward the question of recency of faulting.)

Morton, P.L., Miller, R.V., and Evans, J.R., 1976, Environmental geology of Orange County, California: California Division of Mines and Geology Open File Report (in review), 500 p. Map scale 1:48,000.

(They give an excellent brief description of the fault, with emphasis on recency of activity. They conclude that the fault is seismically active.)

Nicoll, G.A., 1970, Investigation of soil and geologic conditions, feasibility of fill placement, Tonner Canyon, Orange County, CA: unpublished report, W.A. Wahler and Associates, Newport Beach, California; on public file, Orange County Building and Safety Department, Santa Ana, California. [*Not available at San Francisco.*]

Real, C.R., Parke, D.L., and Topozada, T.R., 1977, Magnetic tape catalog of California earthquakes, 1900-1974: California Division of Mines and Geology.

Tepel, R.E., 1971, Final grading report, soils engineering and geology, for Mobil Oil fill, Tonnor Canyon area, Orange County, California: unpublished report by W.A. Wahler and Associates, Newport Beach, CA. [*Not available at San Francisco District office*]

Woodford, A.O., Schoellhamer, J.E., Vedder, J.G., and Yerkes, R.F., 1954, Geology of the Los Angeles Basin, In Jahns, R.H., editor, Geology of southern California: California Division of Mines and Geology Bulletin 170, p. 65-81. Map scale 1:95,000.

(They give a brief, general discussion of the fault.)

Woodford, A.O., Shelton, J.S., and Moran, T.G., 1944, Stratigraphy and oil possibilities of Puente and San Jose Hills, California: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 23. Scale 1:75,000.

(Another early map of the Puente Hills showing the major faults in a very generalized fashion.)

Yerkes, R.F., 1972, Geology and oil resources of the western Puente Hills area, southern California: U.S. Geological Survey Professional Paper 420-C, 63 p. Map scale 1:24,000.

(A moderately detailed map and good description of the fault zone. This report covers only the western half of the Whittier fault.)

5. Summary of available data:

The Whittier fault forms the structural boundary along the southwestern side of the Puente Hills. Morton and others (1976) give the following general description of the fault zone:

The Whittier fault zone extends from Whittier Narrows in Los Angeles County on the northwest to Santa Ana Canyon in the southeast where it merges with the Elsinore fault zone -- a distance of about 24 miles. If the Whittier fault zone is considered to be a northward extension of the Elsinore fault zone, then the total fault zone length would be on the order of 175 miles (see also discussion under 3.3 Structure).

The Whittier fault zone consists of sub-parallel branching and en echelon faults which in any given area might consist of as many as three separate breaks which eventually merge along

their course only to branch again into additional separate faults. On the average the zone is 1 to 2 thousand feet wide with individual fault breaks about 5 feet wide. The general bearing of the zone in Orange County is N 70° W and it dips 65° to 75° NE. Relative reverse fault movement is up on the northeast block a few thousands of feet with attendant right lateral movement perhaps as much as several thousand feet (Yerkes, 1972, p. C29).

Deposits of late Pleistocene age (about 100,000 years B.P.) are clearly displaced by the fault near Horseshoe Bend in Santa Ana Canyon, in the mouth of Brea Canyon, and elsewhere. A trench exposure in Tonner Canyon observed during this study exhibited possible evidence for movement of probable Holocene age (figure 5.1F).

A study of microseismicity by Lamar (1973, p. 23) has concluded that the Whittier fault zone is seismically active based upon the location and number of microearthquakes recorded during the study. In another microseismic study (Combs and Langenkamp, p. 376) the main parts of the Elsinore fault zone were shown to be seismically active. There is no known evidence for surface fault rupture within local historic time (since 1769), but a scarp in a Holocene fan deposit is evident in at least one segment of the Elsinore fault zone near Corona (F.H. Weber, 1974, oral communication).

Yerkes (1972, p. C29) says the fault extends northwestward only to Turnbull Canyon. He recognizes no surface trace beyond that point, but his map (plate 1) shows an inferred fault extending northwestward toward the San Gabriel River (the "Whittier Narrows"). He states that the fault zone juxtaposes Miocene and Pliocene strata (Miocene Puente Formation and Pliocene Fernando Formation, both marine) along most of its length.

Yerkes (1972, p. C29) gives more specific information about the magnitude of offset along the fault:

The vertical stratigraphic separation of upper Miocene strata across the zone increases northwestward from about 2,000 feet near the Santa Ana River to a maximum of about 14,000 feet in the Brea-Olinda oil field area. Farther to the northwest, it decreases to about 3,000 feet in the Whittier narrows of the San Gabriel River.

Yerkes (1972, p. C29) also mentions evidence for right-lateral offset along the fault:

Several southwest-trending drainage courses are deflected 4,000-5,000 feet in a right-lateral sense where they intersect the zone in the east part of the map area (figure 13); drainage courses to the northwest and southeast of this area are not so prominently deflected.

The right-lateral offset of the larger drainages was also discussed in several other reports. Miller and others (1977) state that the total right-lateral offset may have been as much as 12,000 feet (3,700 m). That value is the separation distance, along the Whittier fault, between two northeast-trending faults: the Horseshoe Bend fault (to the southwest of the Whittier fault), and the Scully Hill fault (to the northeast of the Whittier fault). They suggest that these two fault segments at one time constituted a single, through-running, northeast-trending fault that was subsequently cut and offset by the Whittier fault.

Speculative?

The only surface evidence for possible Holocene displacement in or near the Whittier fault zone was from excavation exposures to the north of the Whittier fault in the area between Brea and Tonner Canyons. Two separate faults were observed in these excavations. The first excavation, a test trench, was at location 1, shown on figure 3b of this FER, and the second excavation, a bench cut for fill emplacement at location 2. Lamar (1972, p. 25) gives this account of the first excavation:

The most convincing evidence of Recent faulting near the principal trace of the Whittier fault is described in a report by Nicoll (1970). In test trenches across a fault on the ridge between Tonner and Brea Canyons (plate 1), a maximum of 21 feet of soil or colluvium was observed in fault contact with sandstone of the Soquel Member of the Puente Formation. The fault contact is about 900 feet long. The colluvium is situated on the north side of the fault so that the sense of vertical separation is down on the north side. Nicoll suggests that the colluvium accumulated

In an undrained depression (sag pond) which formed as a result of late Pleistocene and Holocene (Recent) movement on the fault. Topography
pre-Holocene?
The fault was previously mapped by Yerkes and Durham (1964), without the benefit of test trenches; they and Nicoll show the La Vida Member on the north faulted against the Soquel Member of the Puente Formation on the south. The La Vida is older than the Soquel, so a reversal of vertical offset in the older rock units is indicated. The fault strikes east-west, is shown on Nicoll's structure section dipping about 80 degrees north, and lies about 2000 feet north of the inferred principal strand of the Whittier fault in Tonner Canyon.

Miller and others (1977) state that the faulting observed in that trench "... involved soils of possible Holocene age."

Miller and others (1977) give this brief account of the second excavation:

The closer location (location 2), about 1,000 feet (300 m) north of the Whittier fault, is also along a secondary fault subparallel to the Whittier fault and was uncovered during bench cutting for fill placement. It was reported by Tepel (1971) that a soil of probable Holocene age, lying on a terrace deposit, had been cut by faulting.

Miller (oral communication, November 1977) stated that both of the subsurface exposures described above have been backfilled or buried, and can no longer be observed.

Microseismic studies conducted by Lamar (1972) in the area of the Whittier fault suggest that the fault is active. The following summary is taken from the abstract of his report:

A net of portable seismeters was operated in the Whittier area between July 1971 and April 1972. Because of the background noise, the smallest event that could be reliably located had a magnitude of 1.0. Epicenters of 31 microearthquakes with a maximum magnitude of 3.0 were determined, but no direct evidence could be established for a relationship between oil production and waterflood activities and the distribution of microearthquakes. Sufficient data were available to determine hypocentral depths for 17 events. Assuming a range of 60 to 70 degrees north dip on the Whittier fault, 8 of the 17 hypocenters lie on the subsurface projection of the Whittier fault; one hypocenter lies on the Norwalk fault. Eight of the hypocenters cannot be related to any known structure. On the basis of the microearthquakes detected during this study, the Whittier fault must be considered active.

The largest recorded seismic event that is thought to have originated on the Whittier fault was a 4.2 magnitude earthquake that occurred on January 1, 1976. The epicenter was about 2.5 km north of the Whittier fault at the point where the fault crosses the Orange-Los Angeles County boundary.

The epicentral maps (figures 2a and 2b) show a general increase in the density of events in the vicinity of the Whittier fault. Events with hypocenters on the Whittier fault should show epicenters occurring 1 km to 3 km northeast of the surface traces of the fault zone. The "A" quality data (figure 2a) show four events located from 0.2 km to 1.0 km north of the fault zone. However, a prominent cluster of seven events lies 4 to 7 km northeast of the fault zone. Even considering the plus or minus 2 km location error in the "A" quality data, these events would not appear to be generated on the Whittier fault. The "B" quality data (figure 2b) show a fairly clear linear pattern of events that trends parallel to the Whittier fault and lies about 3 to 4 km to the northeast. Considering the plus or minus 5 km location error for these events, it is certainly possible that they may have occurred on the Whittier fault. It is curious to note, however, that there is an even greater number of events with epicenters lying between 2 and 6 km to the south of eastern half of the Whittier fault. These events appear to be not related to any known significant fault. If the linear trend of events to the northeast of the Whittier fault is interpreted as evidence that the fault is active, then what interpretation does one assign to the even greater trend of epicenters south of the Whittier fault?

6. Interpretation of aerial photography: None.

7. Field observations: None.

8. Conclusions:

There has been no surface evidence found that would indicate Holocene movement along the main branches of the Whittier fault. Some workers have ascribed Holocene movement to nearby auxilliary faults in the area between Brea and Tonner Canyons, because materials cut by the faults there were thought to be of Holocene age. As is so often the case, however, no evidence is presented as to why the "Holocene" materials are considered to be that young.

Seismic data indicate that some, and perhaps many events of small magnitude are generated along the Whittier fault within periods of time as short as a year. We do not, however, know the significance of these data. What do they indicate about the probability of seismic events large enough to be accompanied by ground breakage occurring along this fault? I think that the seismic data do not answer our question as to whether or not the fault is "sufficiently active."

9. Recommendations:

On the basis of the available literature and data, I recommend that no part of the Whittier fault zone be zoned at this time. Since DMG personnel have recently conducted detailed studies of the Whittier fault, with the primary purpose of determining the recency of activity along the Whittier fault and other faults in that area, I recommend that we do not conduct any further studies of the fault.

10. Investigating geologist's name and date:

Drew P. Smith

DREW P. SMITH
December 12, 1977

*I agree with
the recommendations.
EJH*

